

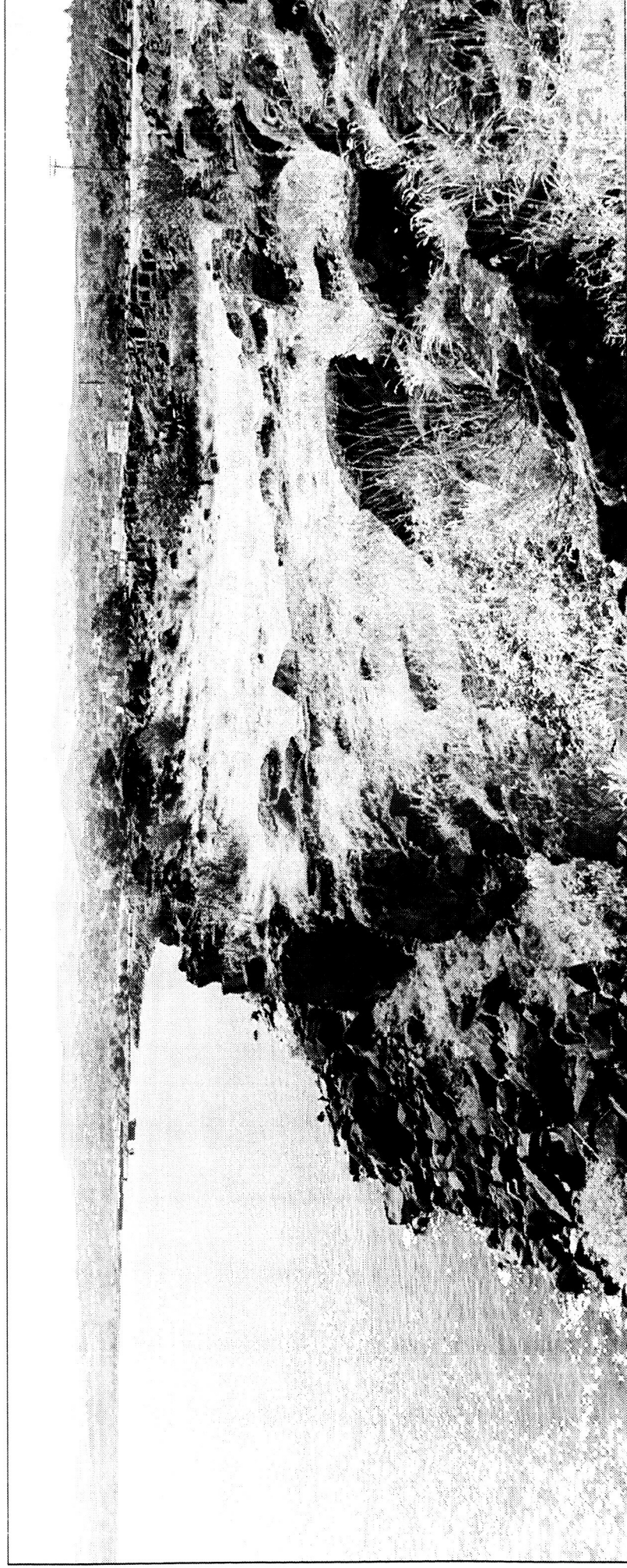
Use of Remote Sensing and GIS in Search for Lewis and Clark's Rock Fort Camp Site of The Dalles, Oregon

Ken Karsmizki¹, Joe Spruce², Marco Giardino³

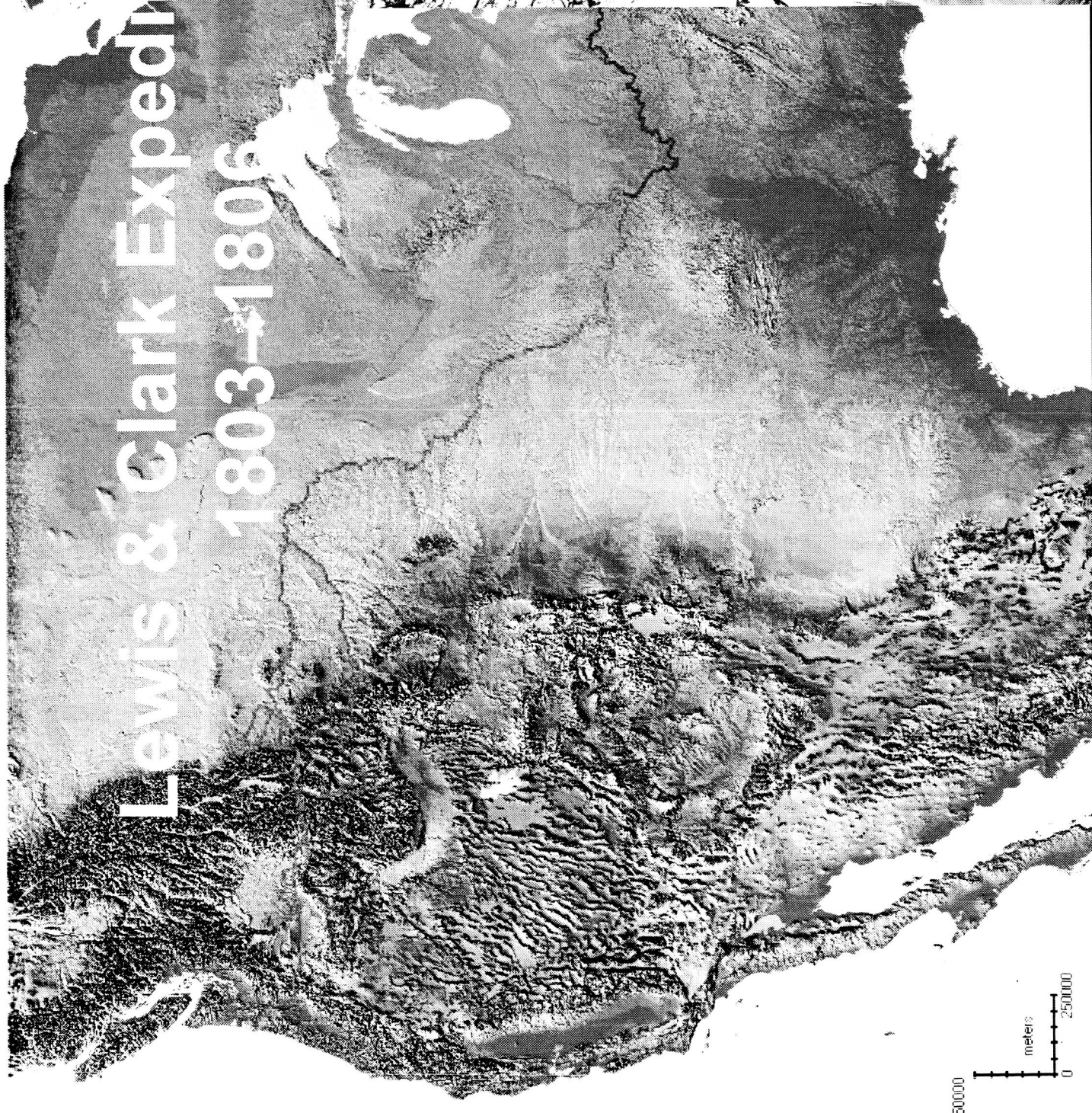
¹Columbia Gorge Discovery Center, The Dalles, Oregon

²Lockheed Martin Space Operations - Stennis Programs, Stennis Space Center, Mississippi

³National Aeronautics and Space Administration, Stennis Space Center, Mississippi



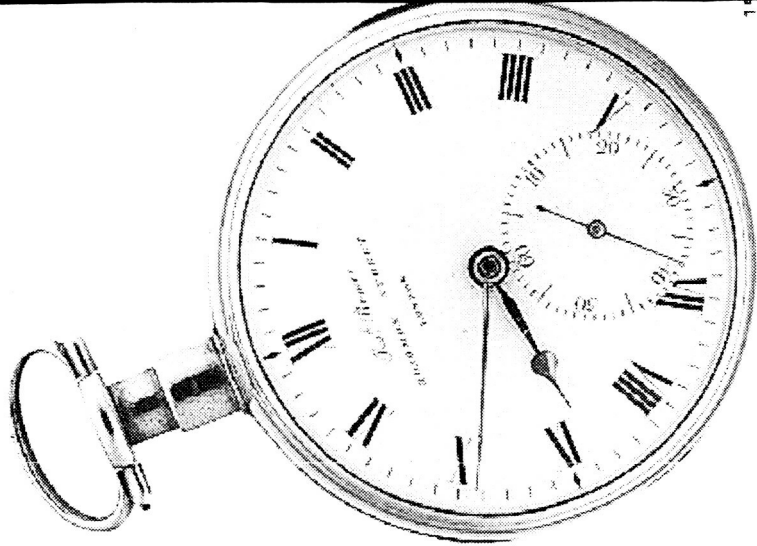
Lewis & Clark Expedition 1803-1806



8,000 Miles

863 Days

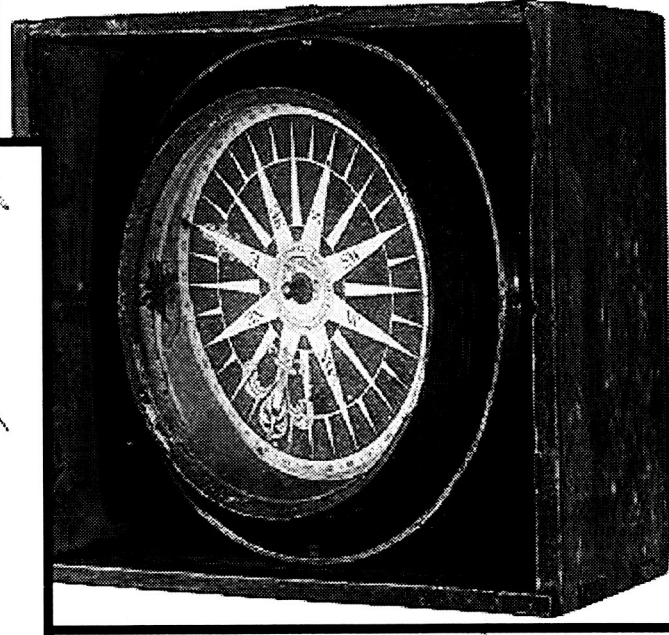
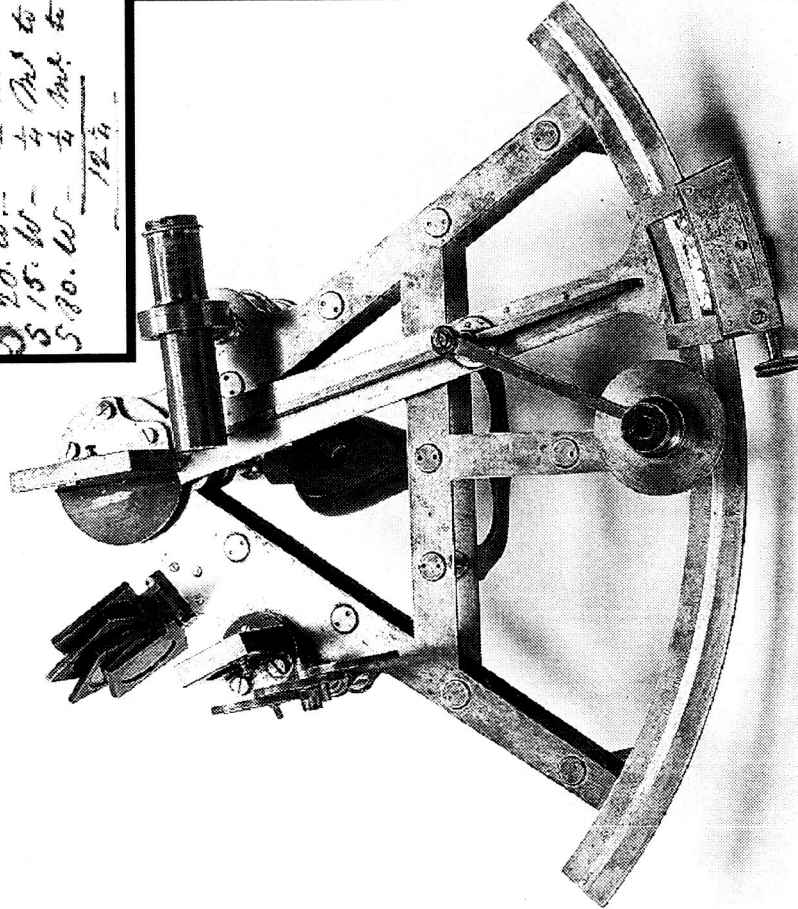
600+ Campsites



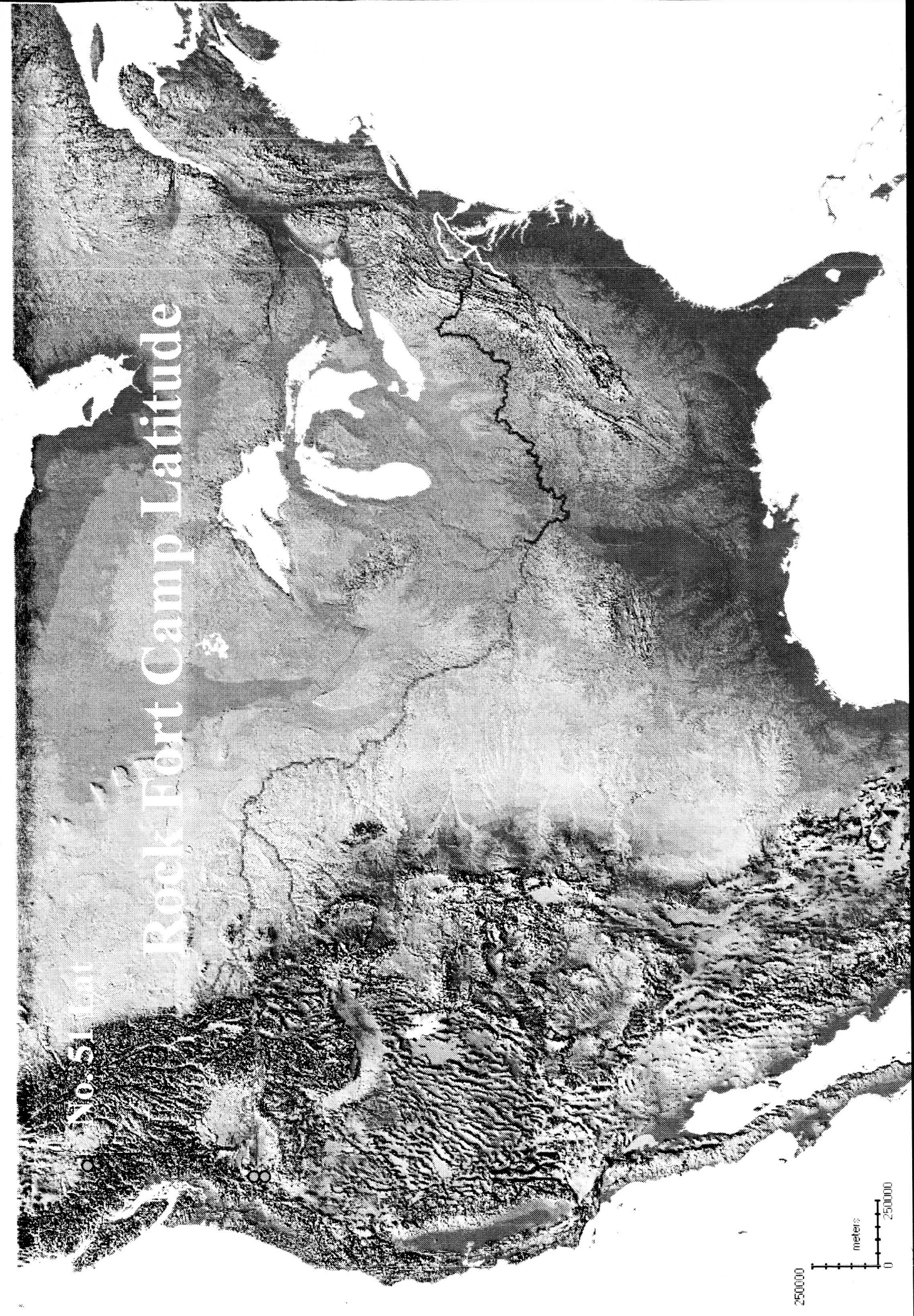
Course Declared as Right July 5th

N. 28. E 1. M. on L. pt. - a Sand bar			
N. 10. W 1 1/2 M. to Low: Pt. of Madawaska R. S.S.			
N. 25. W. 3 M. to a Pt. on land. S. part 2 1/2 M.			
N. 56. W. 1 1/2 M. to S. Pt. of Madawaska R. ②			
W. 2 1/2 M. on the right of the Island			
S. 10. W. 1/2 M. to Pt. on the S. S.			
N. 25. W. 1/2 M. to Pt. on the Island			
N. 40. W. 1/2 M. to a band on the on the S. S.			
N. 70. W. 1/2 M. to do			
S. 70. W. 1/2 M. to do			
N. 82. W. 1/2 M. to do			
N. 12. W. 1/2 M. to do			
S. 50. W. 1/2 M. to do			
N. 60. W. 1/2 M. to do			
N. 13. W. 1/2 M. to do			
N. 33. W. 1/2 M. to do			
S. 20. W. 1/2 M. to do			
S. 15. W. 1/2 M. to do			
S. 20. W. 1/2 M. to do			

do on S. S. of the head of S.



Boat compass, early 1800s



Whitehouse Journal - 45° N. Latitude Clark Map N. 51° Lat. Actual 45° 26' 33"

○ No. 51 Lat

Rock Fort Camp Latitude

○ Actual Lat

○ 45 No. Lat

Whitehouse Journal - 45° N. Latitude

Clark Map N. 51° Lat.

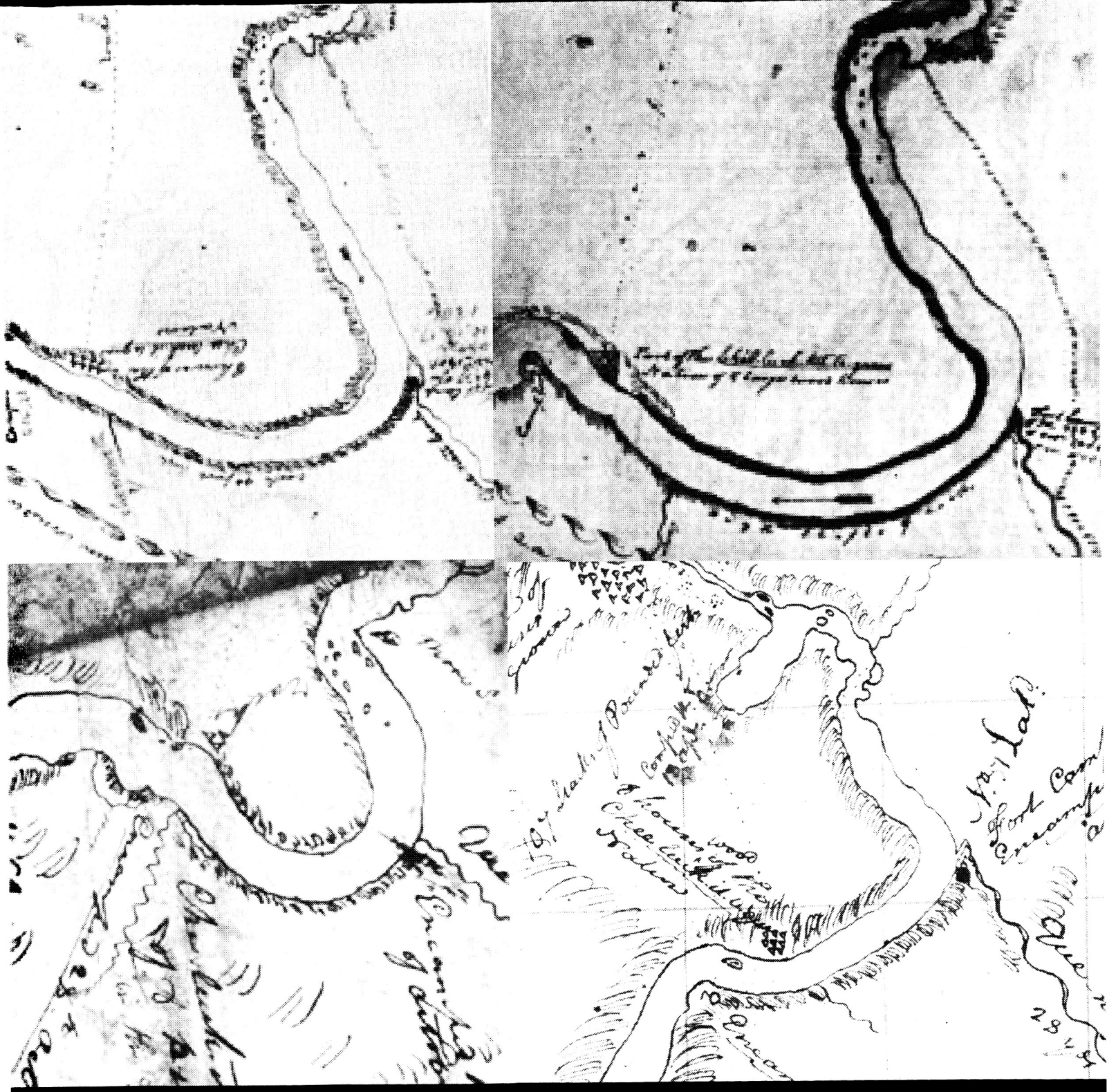
Actual 45° 26' 33"

William Clark was the primary cartographer for the expedition, but that does not mean the maps are consistent in their representation of the landscape.

Here are four different maps of The Dalles, Oregon, that show very different views of that particular landscape.

Which map is most accurate in terms of locations?

Which map has the most useful, diagnostic information?

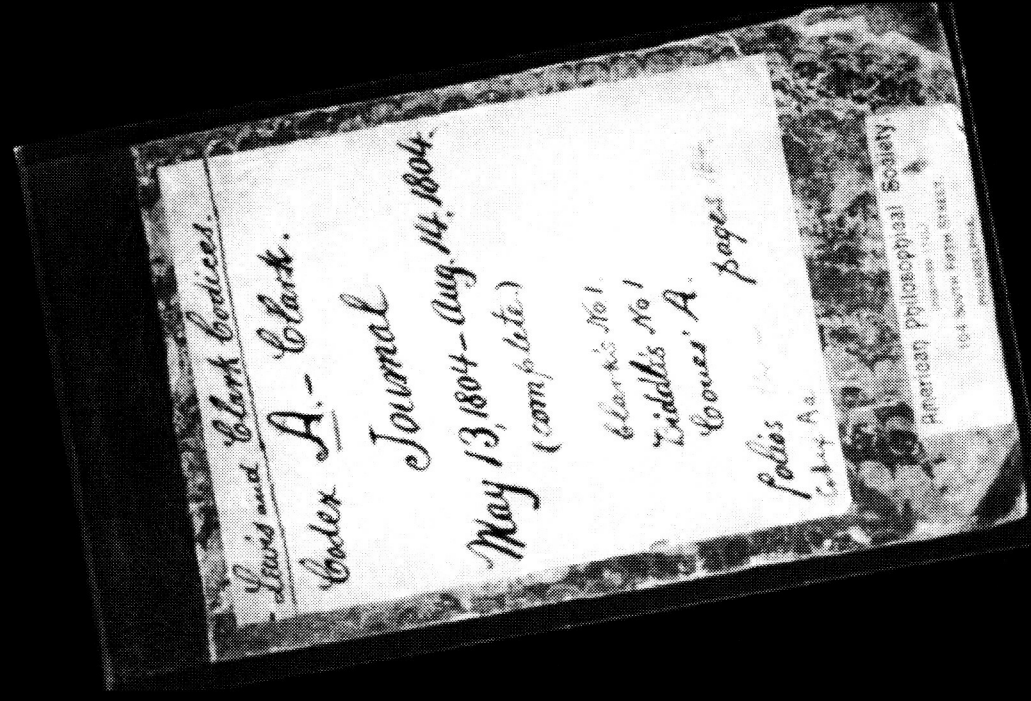


Corps of Discovery Journals

It is assumed that researchers can go to the journals of the expedition to find the precise locations of specific campsites.

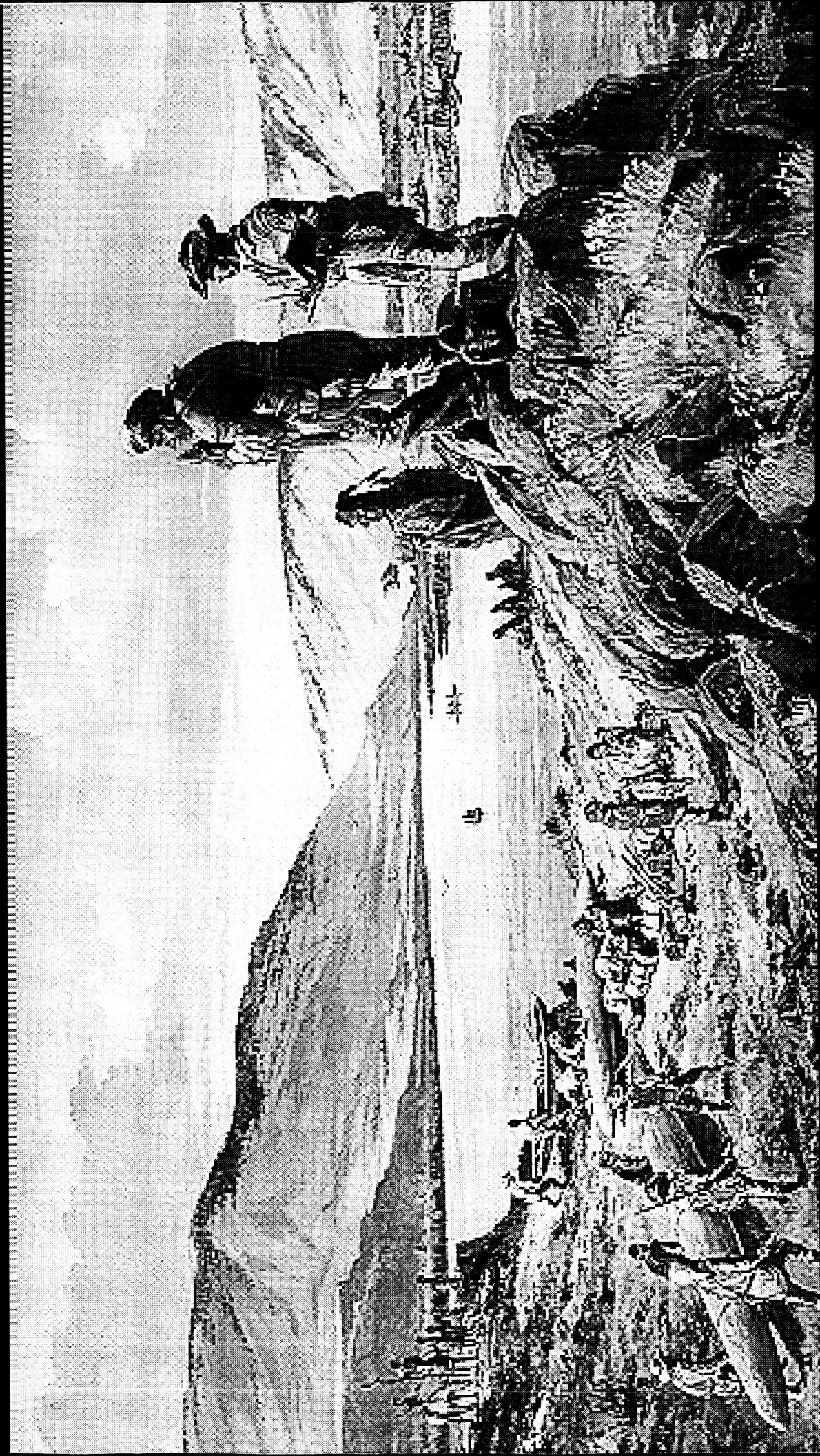
Of the core group of 33 people on the expedition, scholars know that at least 9 individuals kept journals. The location of three of those journals is unknown, and they may have been destroyed.

However, a close examination of the six available journals demonstrates that not everyone described campsite locations the same way, which adds to the confusion.



Journal Entries

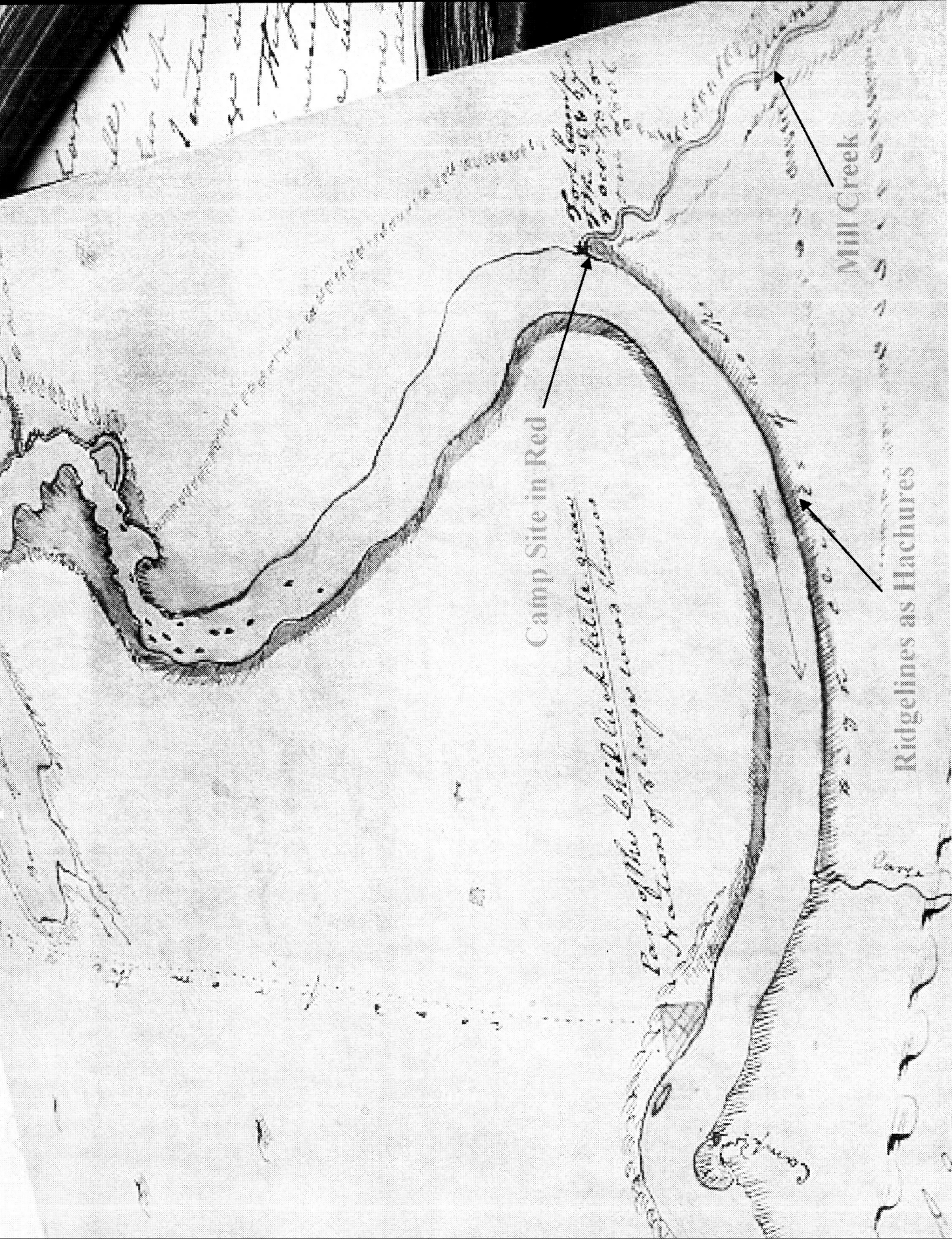
- William Clark, October 25 – “formed our Camp on the top of a high point of rocks, which forms a kind of <artif> fortification”
- Patrick Gass, October 25 – “encamped at the mouth of a creek”
- John Ordway, October 25 – “Camped below the mouth of a creek on a point of rocks”
- Joseph Whitehouse, October 25 – “encamped near a high point of Rocks”
- Whitehouse, October 25 – “Camped, on a high point of rocks”
- Whitehouse, October 26 – “Encampment near the point of rocks”
- Whitehouse, October 26 – “lay camped on the clift or pt. Of rocks



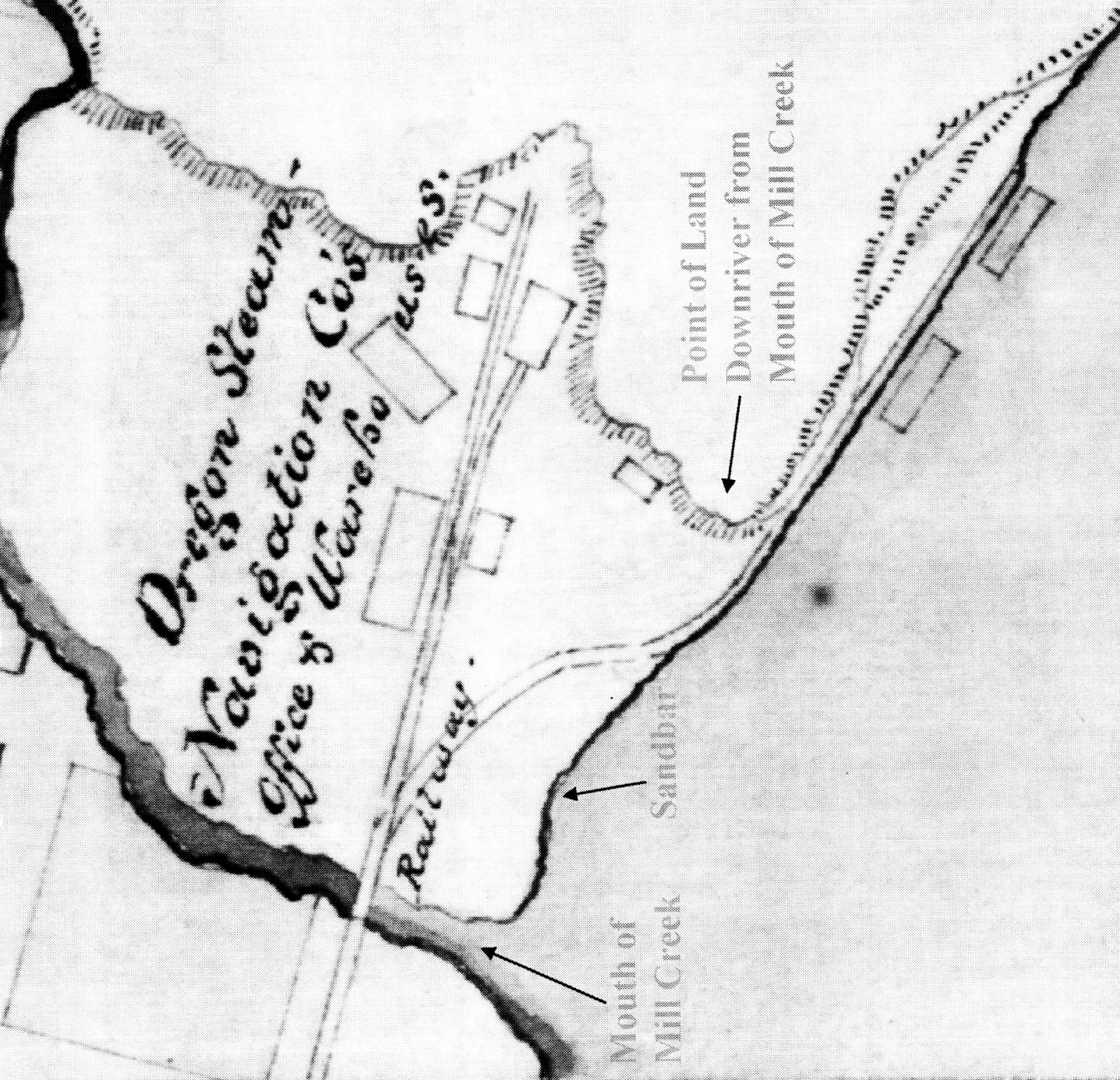
Rock Fort Mural, The Dalles, Oregon

Although this is an interesting artist's rendition of the Rock Fort campsite, it is unlikely that the expedition's canoes were hauled to and repaired at the campsite. A 20-foot cliff limits access to the site, and the journals indicate that a guard was placed with the canoes.

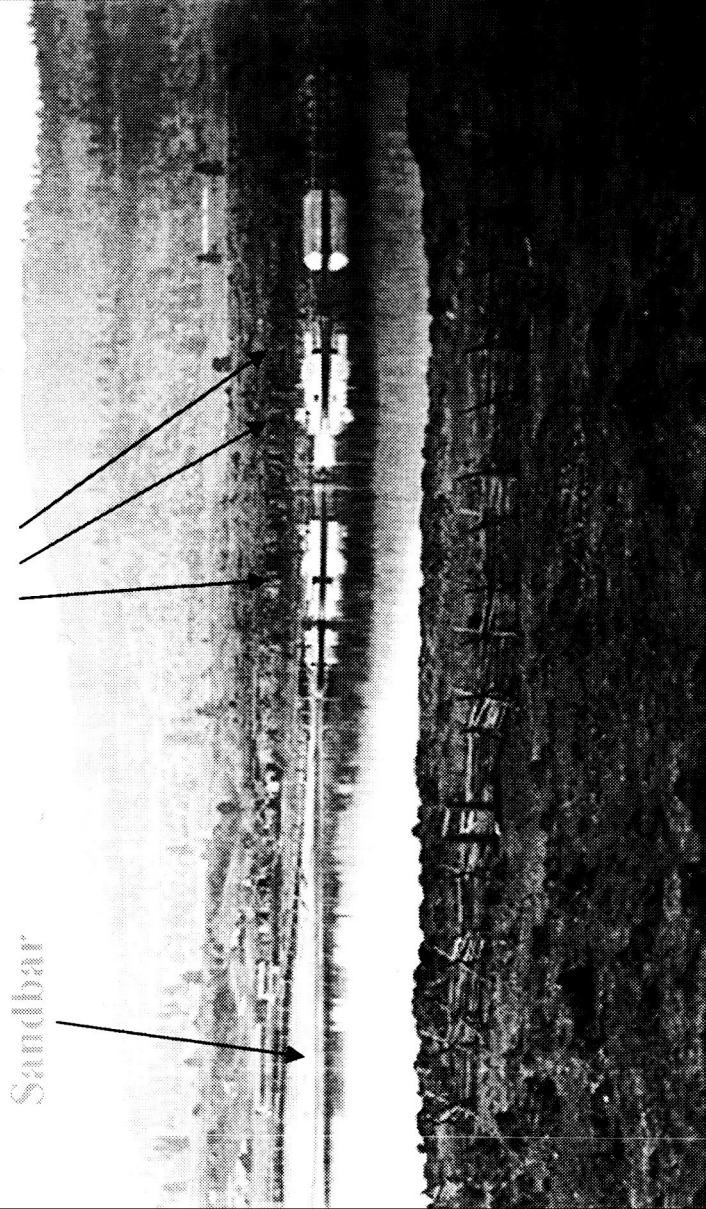
Geological Expedition Map by William Clark



1800s Map Excerpt Showing Mouth of Mill Creek



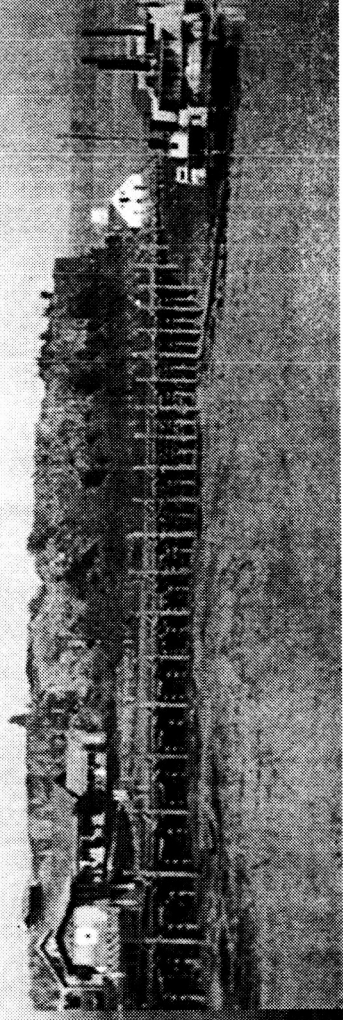
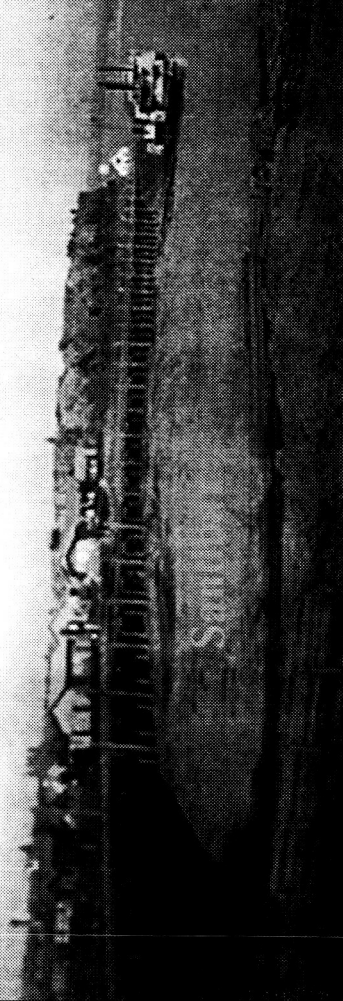
Columnar Basalt Cliff

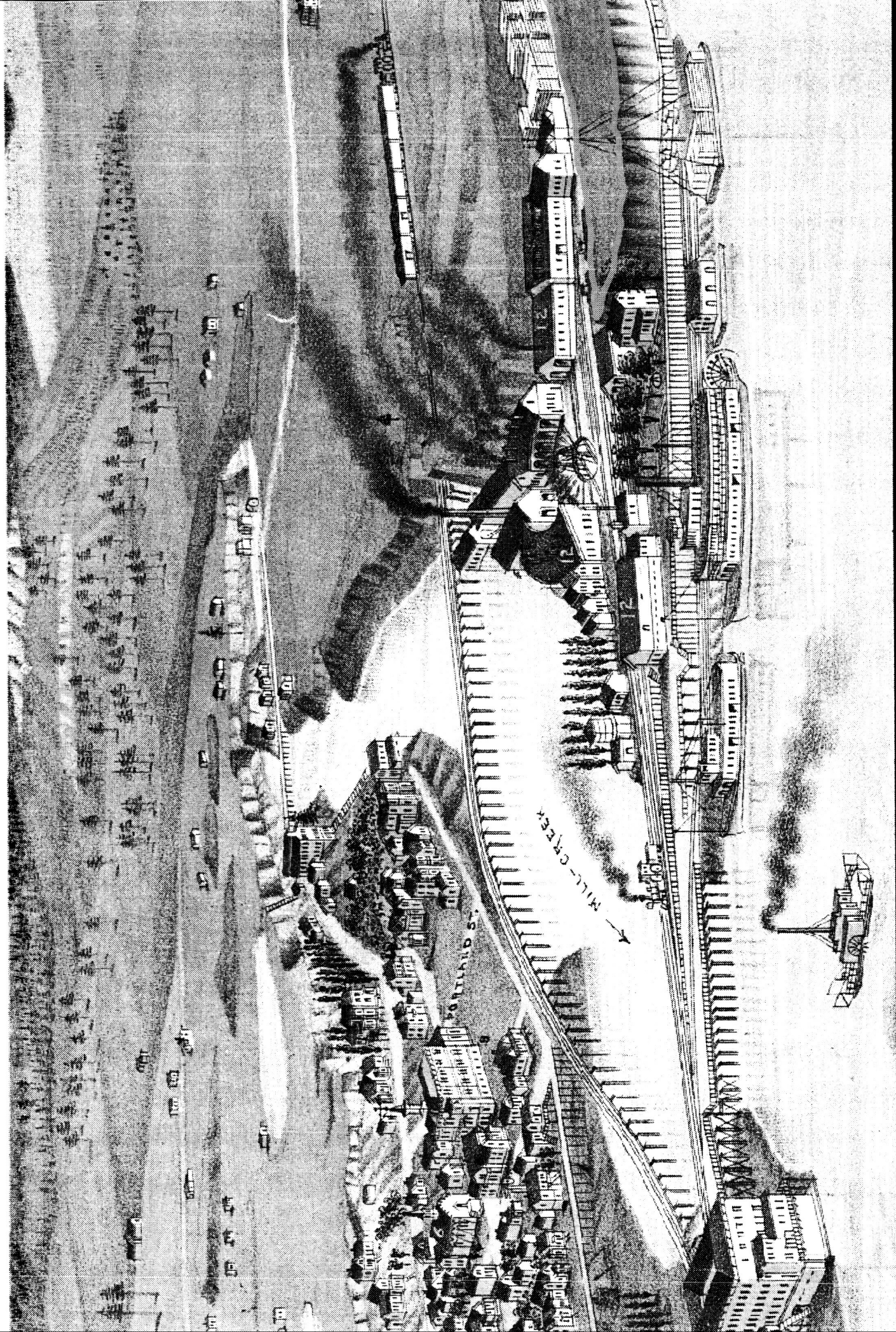


1867 Views

Point of Rocks
that was probable site of
Rock Fort

Zone Containing
Generally Accepted Location





An 1884 panorama of The Dalles shows Mill Creek, known by Lewis and Clark as Quinette Creek. The “high point of rocks” in the right foreground is as yet undisturbed.

Oblique Projection of 1935 Aerial Photograph Using VirtualGIS Software

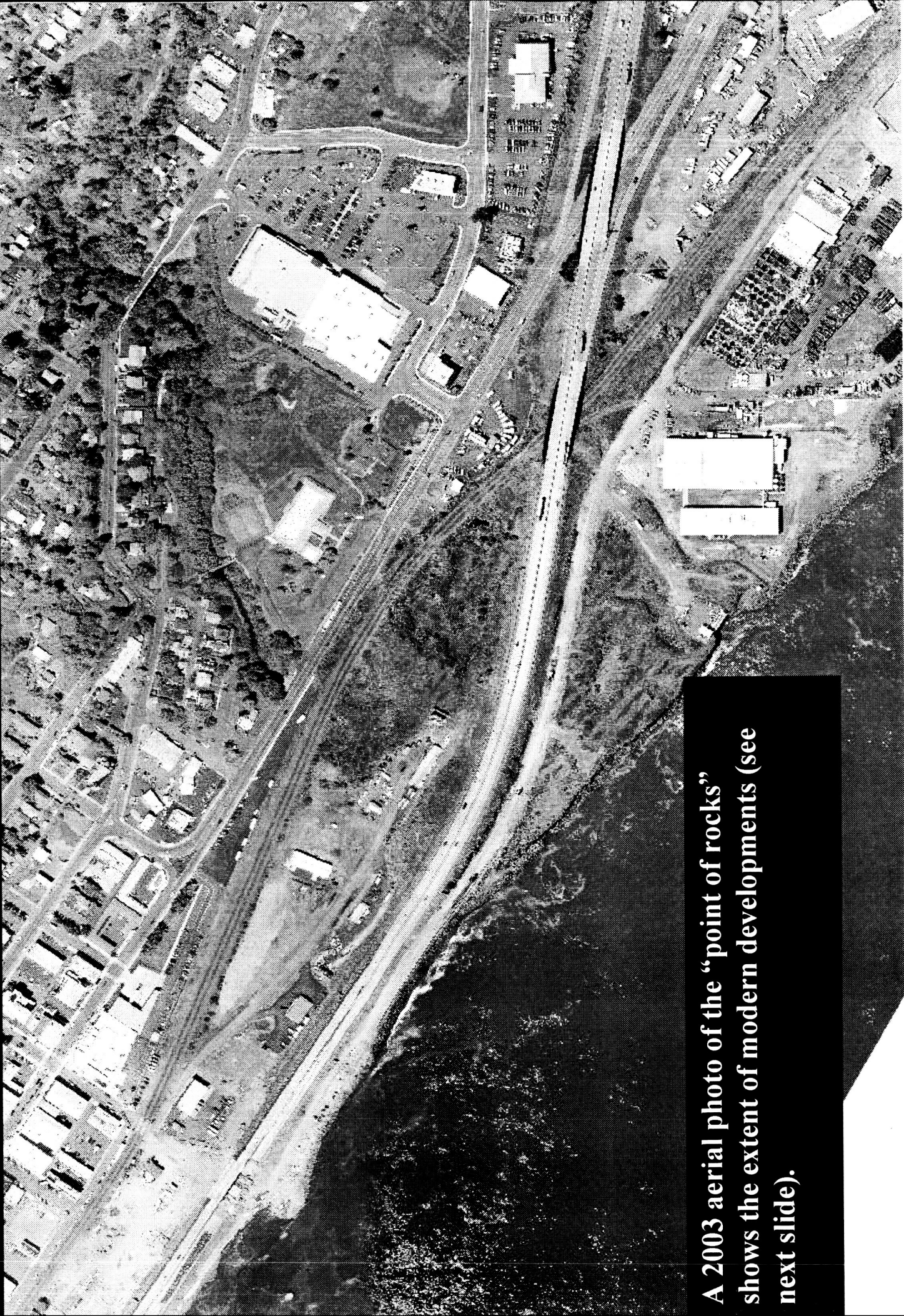


Example of aerial photo taken before damming of the Columbia River.

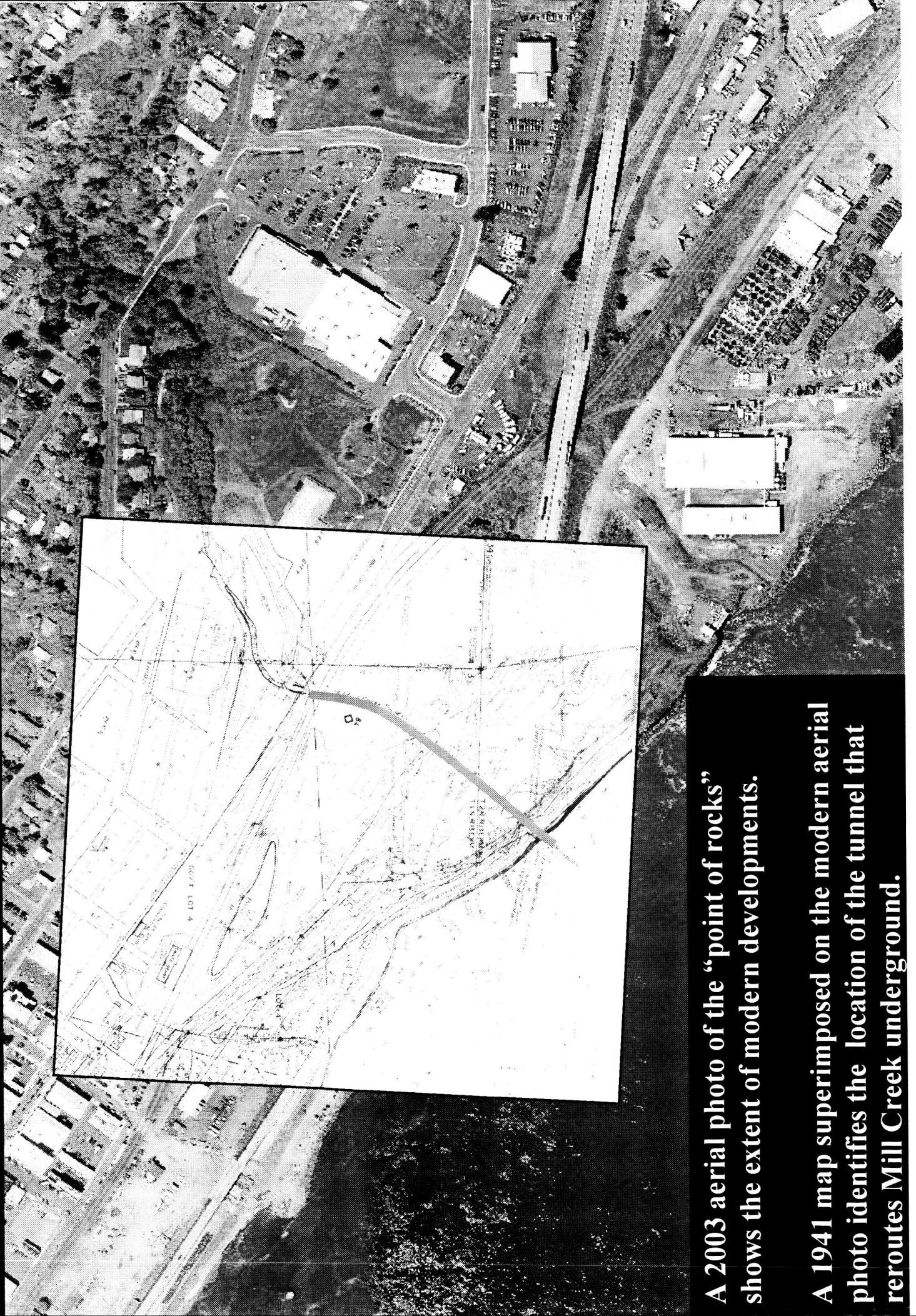
Same 1935 Aerial Photo Annotated with Zone Containing Rock Fort Site



How do we define the boundaries of the point of rocks? The area “inland” from the red zone is too far away from the Columbia to allow ready communication and access to the canoes.

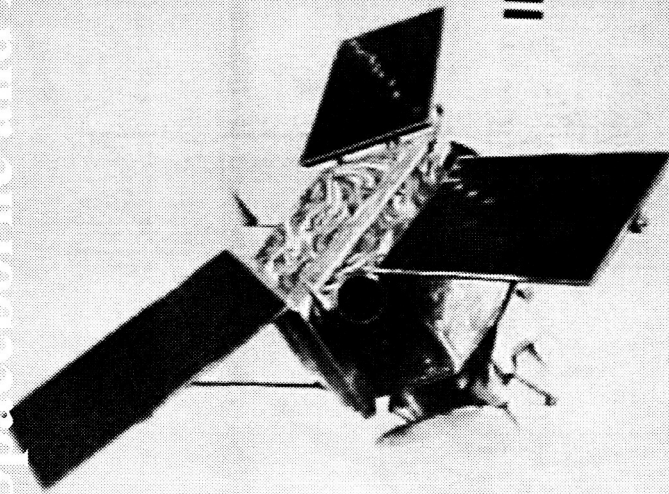


A 2003 aerial photo of the “point of rocks” shows the extent of modern developments (see next slide).



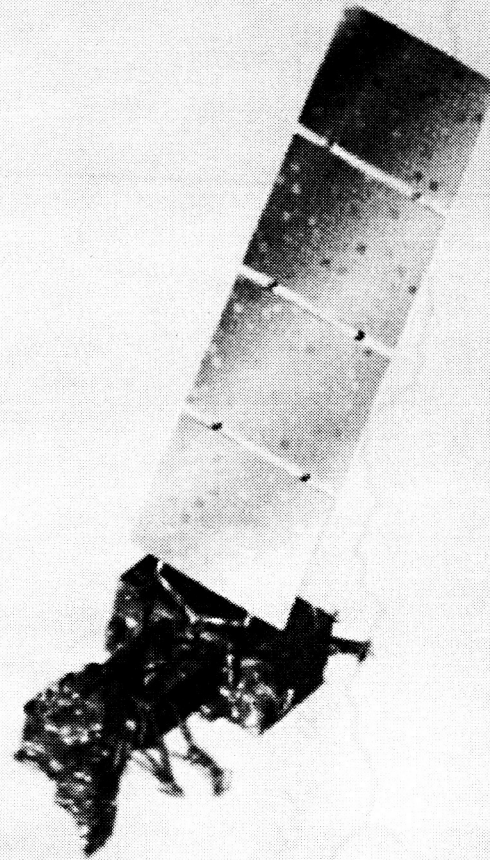
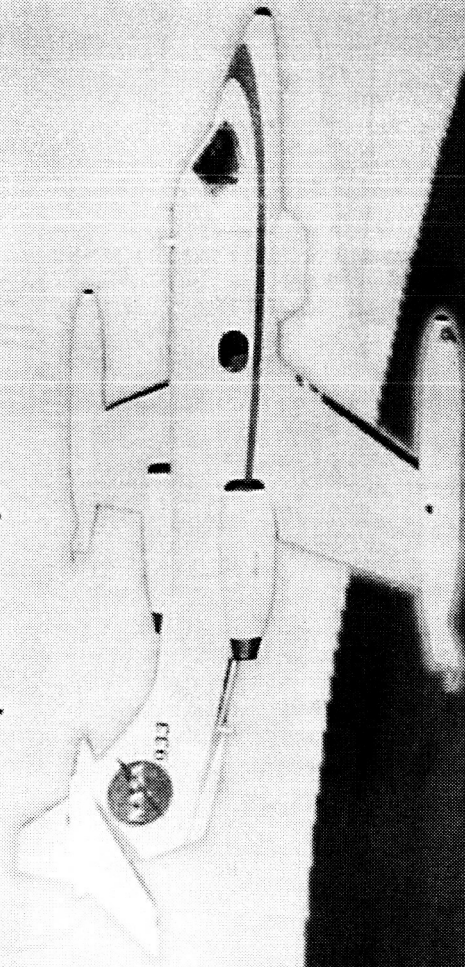
A 2003 aerial photo of the “point of rocks” shows the extent of modern developments.

A 1941 map superimposed on the modern aerial photo identifies the location of the tunnel that reroutes Mill Creek underground.

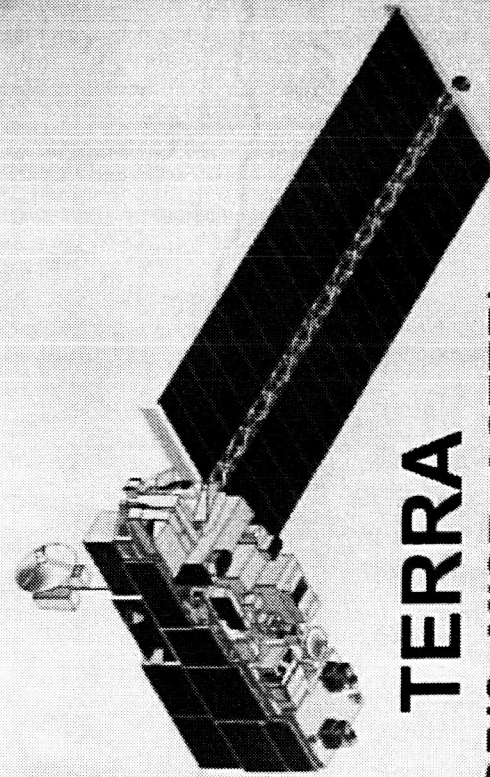


IKONOS

Airborne Sensor (ATLAS)



**Landsat 7
(ETM+)**

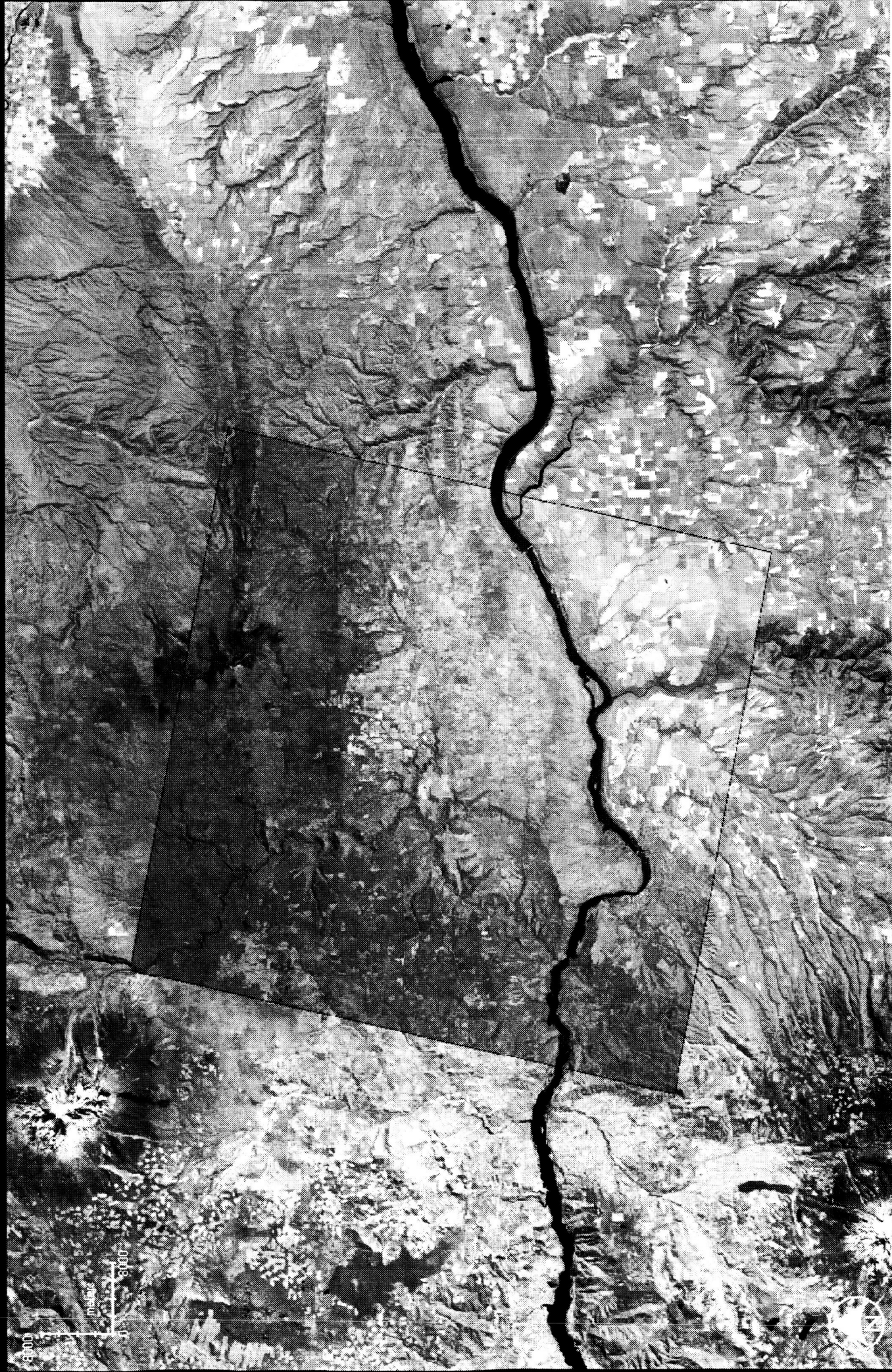


**TERRA
(MODIS, MISR, ASTER)**

Space Shuttle Image Georegistered to Landsat Image of The Dalles Area



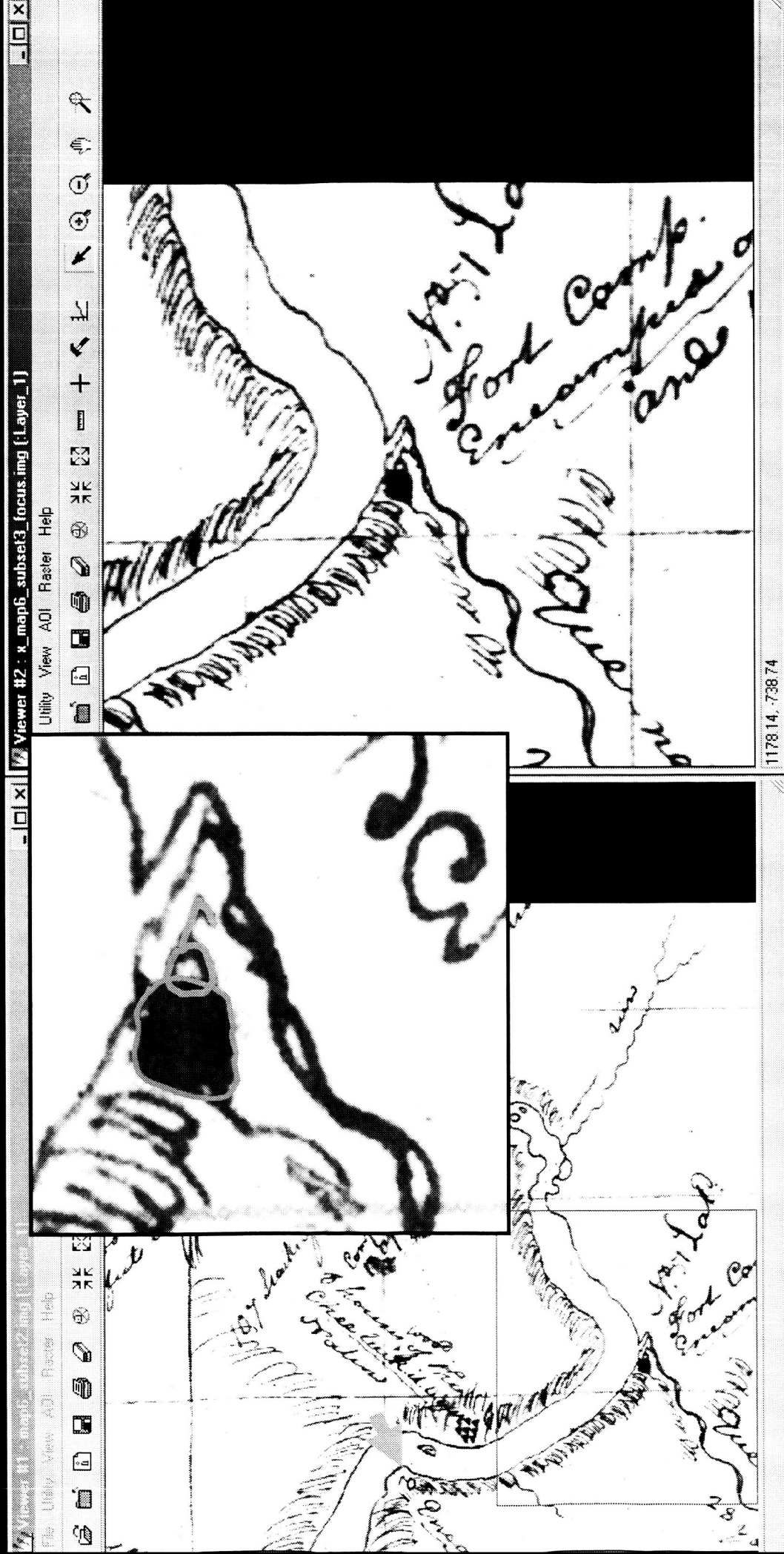
ASTER Imagery Georegistered to Landsat Image of The Dalles Area



ASTER Imagery Georegistered to Landsat Image of The Dalles Area



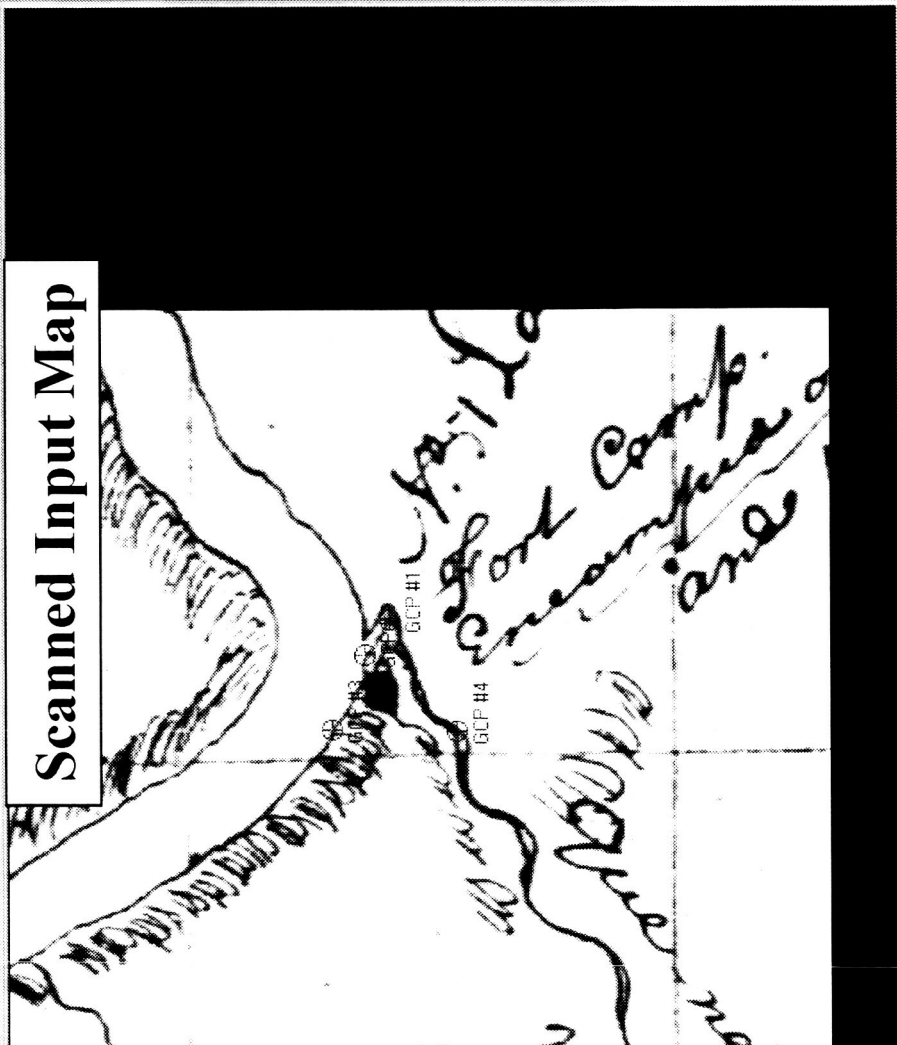
Defining Focus Area For Georeferencing Clark's Map



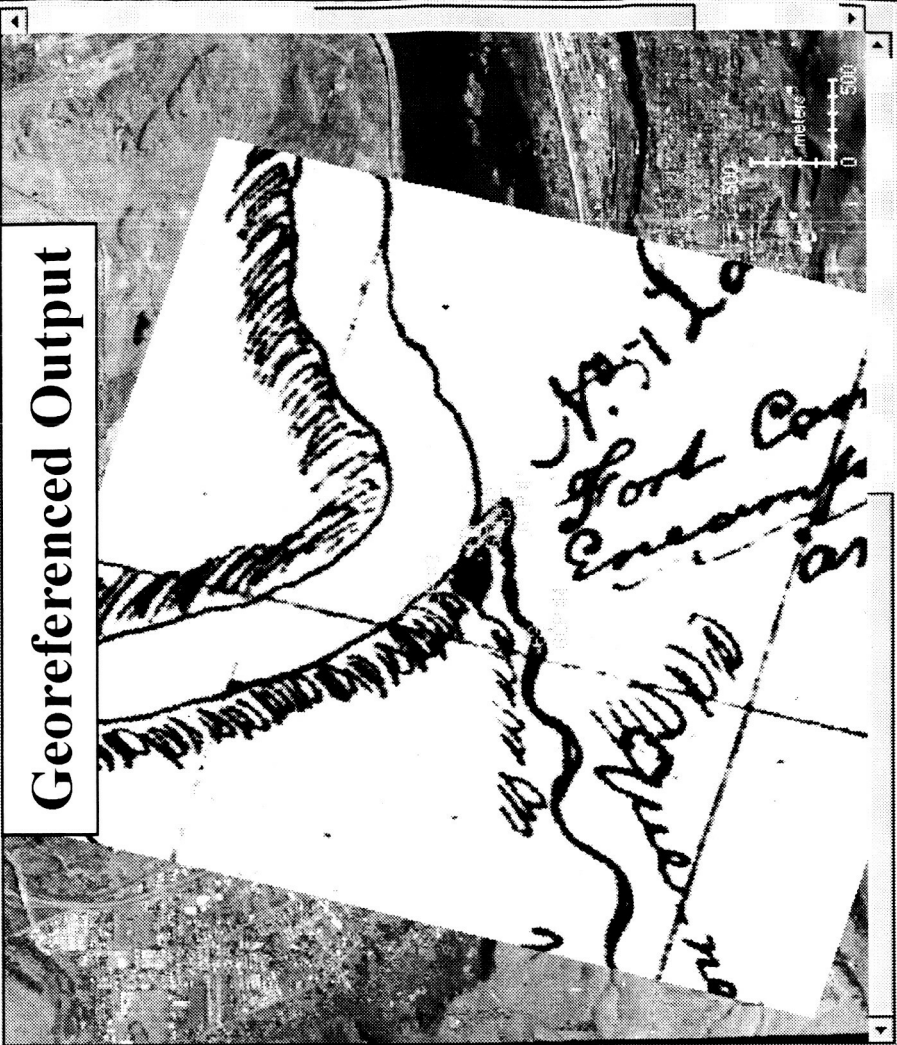
**Clark's Map of The Dalles Area
(Focus Area in Red)**

Zoom of Target Area

**Note black spot, creek hooking back,
and circle with stem and flag**



Scanned Input Map



Georeferenced Output

644372.06, 5049727.29 (UTM / WGS 84)

Control Point Error (X) 2.5047 (Y) 0.7683 (Total) 2.6199

Point #	Point ID	X Input	Y Input	X Ref.	Y Ref.	Type	X Residual	Y Residual	RMS Error	Contrib.	Match
1	GCP #1	1440.314	-1004.299	641529.875	5051633.020	Control	2.970	-0.911	3.107	1.186	
2	GCP #2	1462.153	-1019.714	641424.849	5051862.334	Control	-3.857	1.183	4.034	1.540	
3	GCP #3	1507.463	-1039.689	641015.923	5052232.442	Control	1.152	-0.353	1.205	0.460	
4	GCP #4	1508.938	-962.974	640825.802	5051462.683	Control	-0.266	0.082	0.278	0.106	
5	GCP #5					Control					

The most relevant portion of Clark's map was georegistered with control points from geospatial reference data (e.g., IKONOS) and a first-order polynomial transformation equation. The output was later used to digitize targeted feature locations.

Extracted GIS Vectors from Clark Map vs. IKONOS Imagery



Detail of Clark's Map



Detail of IKONOS 1-meter Image

- Computer-digitized course of Mill Creek, the rock outcrop feature, and two target areas; pink dots are possible campsite locations.
- Cyan line is screen digitized from georeferenced expedition map by Clark, while yellow line is interactively adjusted to better fit reference data.

Extracted GIS Vectors from Clark Map vs. 1935 Aerial Photo

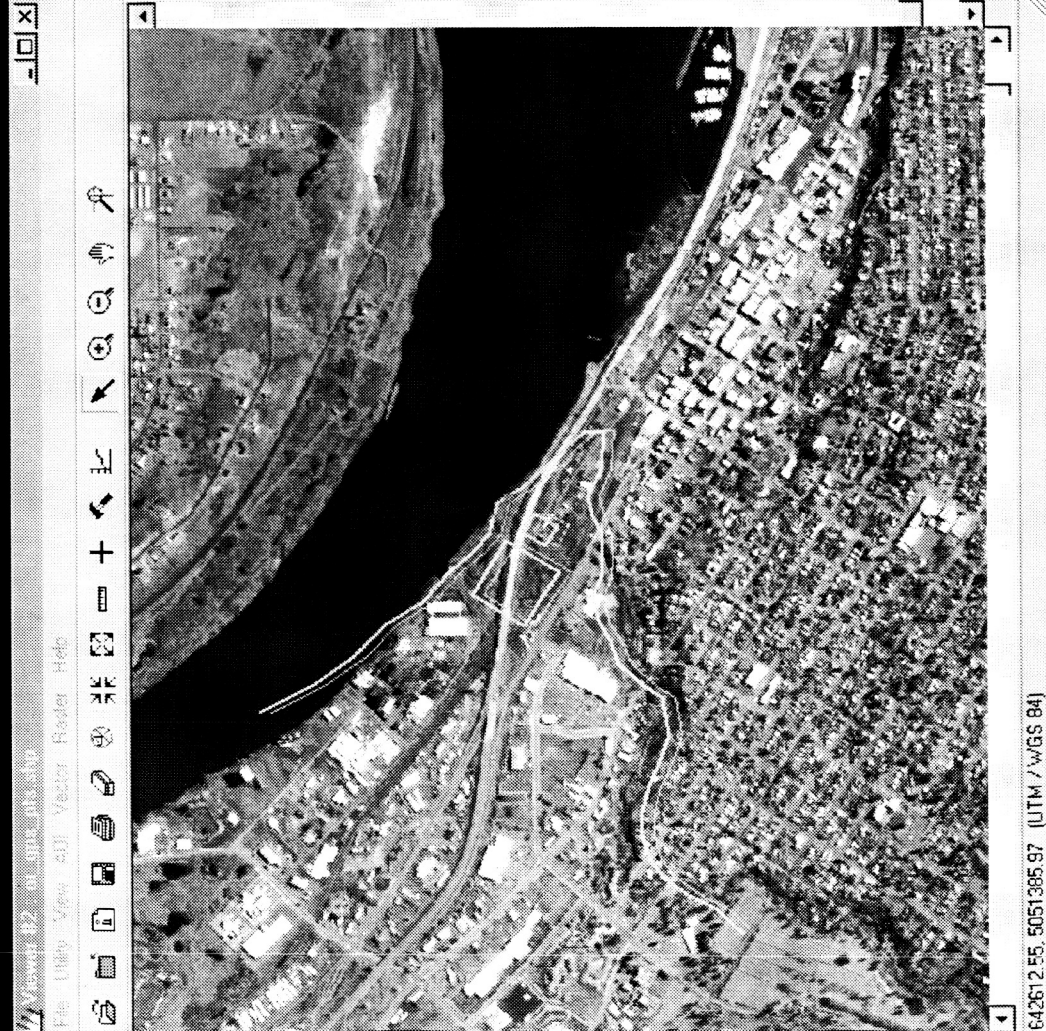


Detail of IKONOS Image

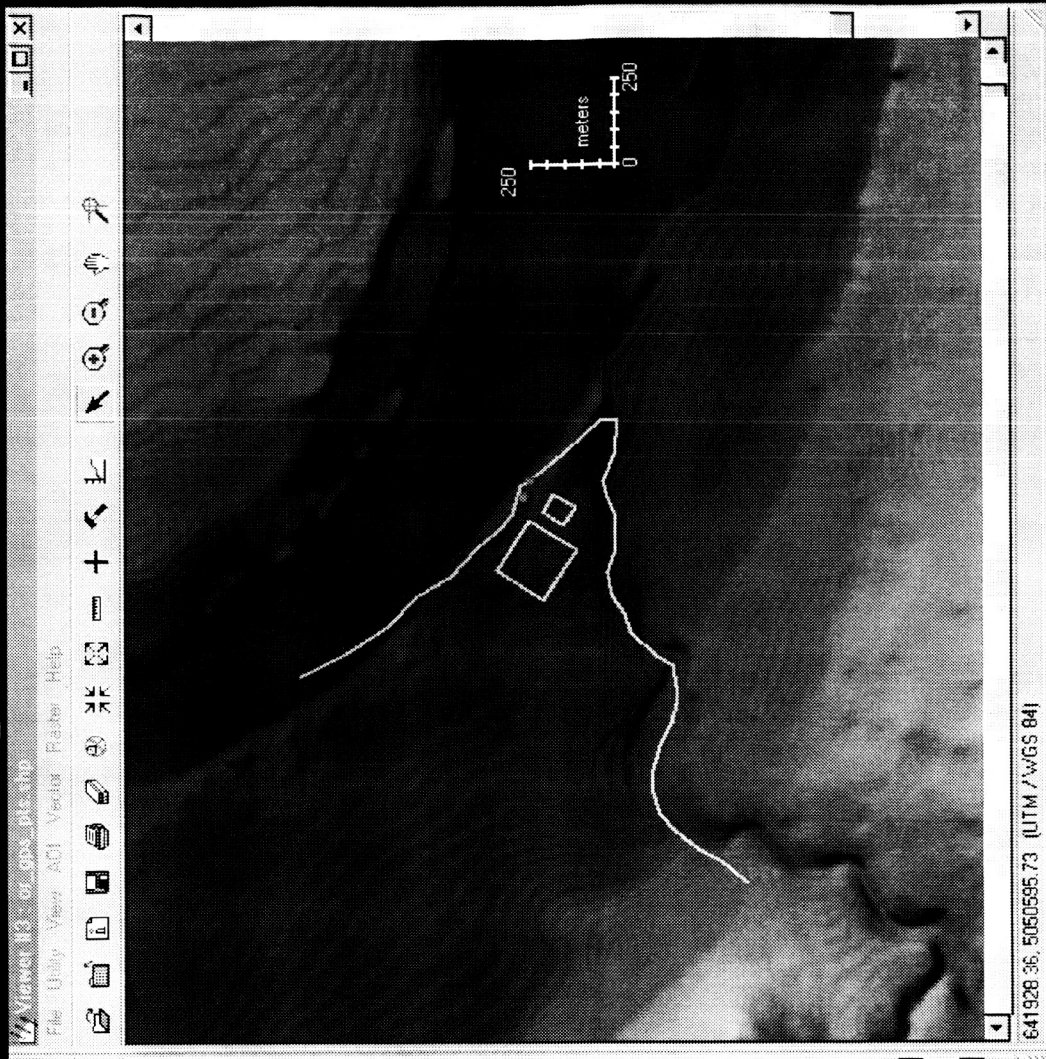
Detail of 1935 Aerial Photo

Note: IKONOS image shows the location of I-84 in relation to the two target squares centered on the rock outcrop. Site disturbance was assessed by comparing modern and historic aerial and map data.

Extracted GIS Vectors from Clark Map vs. Terrain Map



Detail of IKONOS Image



**Detail of Digital Elevation Model
Source: USGS 10-meter DEM**

Zoom of 1935 Aerial

100
meters
0 100

Clark Map Vectors in Yellow
Circa 1935 Development in Red



**Oblique 1935 Aerial of Lower Mill Creek Showing Development In
Vicinity of Expedition's Camp of October 25-28, 1805**



Oblique 2002 IKONOS View of Lower Mill Creek Showing Modern Development In Vicinity of Rock Fort Camp



A 1955 aerial shows a different view of where the expedition may have camped.

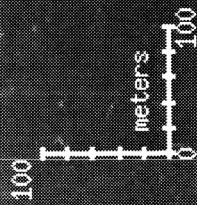
Clark described “a High point of rocks, Which forms a kind of <artif> fortification in the Point between the river & Creek.”

The “point of rocks” landscape is basalt flows characterized by a multitude of natural depressions surrounded by exposed rock walls.

But which is the natural fortification that the expedition selected for its Rock Fort camp?



Modern Development Overlay on 1935 Aerial



Frontage
Road

Railroad

I-84

Note – Vectors from Clark's Map
Were Used Only to Confirm
General Location

Modern Features – Red
Potential Camp Sites – Green
Vectors from Clark's Map – Yellow



Those same three areas on a modern aerial photograph are shown outlined here.

Area 1 is the locally accepted site for the expedition's Rock Fort campsite. This site has had impact from the Construction of Barge Way.

Area 2 has been used in modern times as a parking lot. Because of the cliff, this area has the most logical access to the shore of the Columbia River. Barge Way has also had an impact on the edge of this area.

Area 3 has been pretty much overlooked as a possible expedition campsite. But it is the largest of the three depressions and has not experienced the modern construction impact.



On-Site View of “Area 1” Toward Old Mouth of Mill Creek



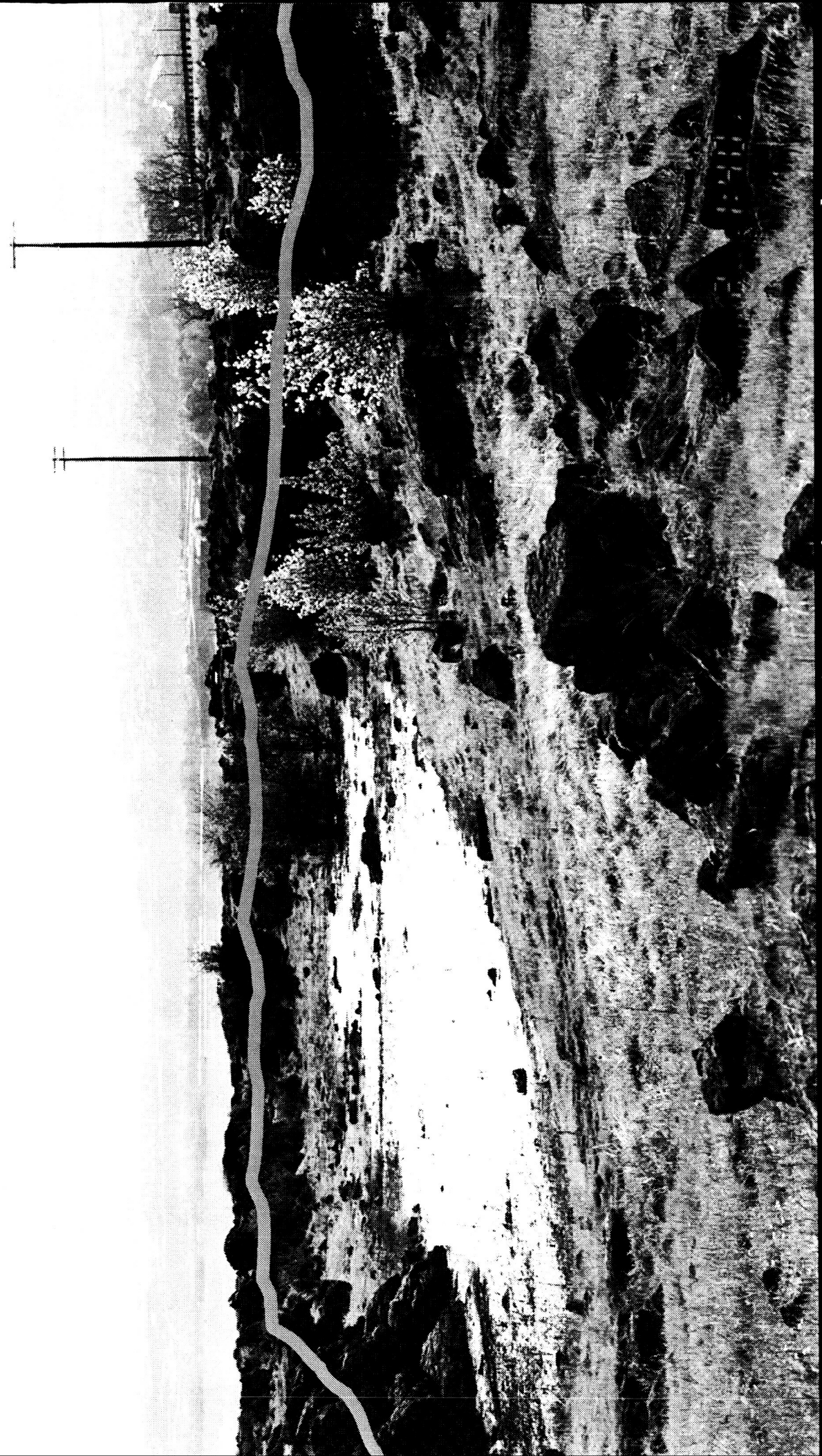
Today Area 1 looks like this in the Fall. The “natural” rock walls that would aid in defense can be seen around the outside of this depression.

On-Site View of “Area 2”



Gravel has buried the natural surface of Area 2; however, removal of the gravel should expose the natural surface and potentially undisturbed archaeological resources.

On-Site View of "Area 3"



Around Area 3, the rock walls enclosing this depression are more pronounced.

Note the reflection in standing water. This water is not present in the October dry season when the expedition camped at Rock Fort heading west but is typical of the April wet season when they returned.

Another On-Site View of "Area 3"



Another view of Area 3 shows less standing water and more of the natural rock walls.

What is interesting about this location is that on the eastbound trip, the journals mention stopping at Rock Fort, deciding not to stay, proceeding to Quinette Creek, traveling up this creek a short distance, and camping under the cliff.

Example of Fortification Features at “Area 3”





Another interesting feature of Area 3 is that someone at some time in the past constructed stacked rock walls. When was this done and what was the purpose? Could it have been to improve the defensive qualities of a sentinel's station at this natural "rock fort" in Area 3?

Concluding Remarks

View from The Dalles

Summary of the Survey and the Data Collected

Needed to Do Archaeological Surveys of the Area Containing Lewis and Clark's Rock Fort Camp

- Geospatial Data and Technologies Enabled The Targeted Area to Be Effectively Narrowed to Focus Future Non-Destructive Geophysical Surveys (e.g., GPR)
- Results Thus Far Have Also Been Useful for Planning Future Synoptic Remote Sensing of Site Terrain with Airborne LIDAR

For More Information:

Ken Karsmizki – kkars@gorgediscovery.org

Joe Spruce – Joseph.Spruce@ssc.nasa.gov

Marco Giardino – Marco.Giardino@ssc.nasa.gov

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
<p>The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p> <p>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</p>					
1. REPORT DATE (DD-MM-YYYY) 08-10-2004		2. REPORT TYPE Final		3. DATES COVERED (From - To) 2002-2004	
4. TITLE AND SUBTITLE Use of Remote Sensing and GIS in Search for Lewis and Clark's Rock Fort Camp Site of The Dalles, Oregon				5a. CONTRACT NUMBER NAS13-650	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
				5d. PROJECT NUMBER	
6. AUTHOR(S) Karsmizki, Ken Spruce, Joe Giardino, Joe				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Columbia Gorge Discovery Center & Museum, 5000 Discovery Drive, The Dalles, OR 97058 Lockheed Martin Space Operations - Stennis Programs, Remote Sensing Directorate, Bldg. 1105, SSC, MS 39529 NASA Earth Science Applications Directorate, Code MA00, Bldg. 1100, SSC, MS 39529				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) NASA Earth Science Applications Directorate, Code MA00, Bldg. 1100, SSC, MS 39529				10. SPONSORING/MONITOR'S ACRONYM(S) NASA ESA	
				11. SPONSORING/MONITORING REPORT NUMBER SSTI-2220-0013 (Original)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Publicly Available STI per form 1676					
13. SUPPLEMENTARY NOTES Presentation at the ESRI User Conference - Lewis and Clark Special Interest Group Meeting, San Diego, CA, August 9-13, 2004					
14. ABSTRACT This presentation describes a segment of a NASA Space Act Project regarded as the "Lewis and Clark Imaging Project" and reports on use of NASA remote sensing and GIS technologies in locating and assessing the Rock Fort site, a Lewis and Clark Expedition camp used in 1805 and 1806.					
15. SUBJECT TERMS Remote sensing, geographic information system, GIS, Lewis and Clark, Rock Fort Camp, Corps of Discovery, VirtualGIS, aerial photo, IKONOS, ATLAS, Landsat, Terra, Aster, digital elevation model, DEM					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19b. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Marco Giardino
U	U	U	UU	39	19b. TELEPHONE NUMBER (Include area code) (228) 688-2739